Landsat 8 Reference Parameters

Spatial and Temporal Coverage

1) The System shall provide a nadir-pointing imaging opportunity for all the 185 km x 180 km scenes identified in the Landsat Worldwide Reference System-2 (WRS-2) grid at least once every 16 days.

2) The System shall collect image data on the sunlit earth with an equatorial local solar crossing time of 10:00 AM +/- 15 minutes.

3) The System shall collect and archive an average of at least 400 individual WRS-2 scenes per 24 hour period; averaged over any WRS-2 observation period.

4) The System shall collect data for all spectral bands within a two-minute period for any point within a single scene observed by the System.

Spectral Bands

5) The System shall collect image data for each of the spectral bands specified in Table 1.

6) Greater than 98% of the total spectral radiance response for each spectral band shall be contained between the 0.01 response points of the relative spectral response curve. The integrated responses will be weighted by the solar TOA irradiance summed with the irradiance from a 300K blackbody.

Table 1 System Spectral Image Data Performance Requirements

#	Spectral Band	Center Wavelength (nm)	Center Wavelength Tolerance (nm)	Minimum Lower Band Edge (0.5 response) (nm)	Maximum Upper Band Edge (0.5 response) (nm)	Maximum Lower Edge Slope Interval; 0.01 to 0.5 (nm)	Maximum Upper Edge Slope Interval; 0.5 to 0.01 (nm)
1	Coastal Aerosol	443	2	433	453	15	15
2	Blue	482	5	450	515	25	25
3	Green	562	5	525	600	25	25
4	Red	655	5	630	680	25	20
5	NIR	865	5	845	885	25	20
6	SWIR 1	1610	10	1560	1660	40	40
7	SWIR 2*	2200	10	2100	2300	50	50
8	Pan**	590	10	500	680	50	50
9	Cirrus	1375	5	1360	1390	15	15
10	Thermal 1	10800	200	10300	11300	400	400
11	Thermal 2	12000	200	11500	12500	400	400

* Minimum bandwidth is 180 nm for band 7

** Minimum bandwidth is 160 nm for the panchromatic band

Spatial Resolution and Response

7) The System image data shall have a distinct pixel edge such that the response to a unit step function/edge as measured by the edge slope is no less than the values in Table 2.

8) The System image data shall be adequately sampled such that the product of the edge slope and the Ground Sample Distance is equal to or less than 1.0.

9) The System image data shall meet the Ground Sample Distance requirements specified in Table 2.

Table 2 System Image Data Spatial Performance

#	Spectral Band	Maximum Ground Sample Distance at	Edge Slope (1/m)
1	Coastal	30	0.027
2	Blue	30	0.027
3	Green	30	0.027
4	Red	30	0.027
5	NIR	30	0.027
6	SWIR 1	30	0.027
7	SWIR 2	30	0.027
8	Panchro	15	0.054
9	Cirrus	30	0.027
1	Thermal	120	0.007
1	Thermal	120	0.007

10) The System shall provide stray light rejection as specified in Appendix A.

11) The System shall control image ghosts as specified in Appendix B.

Radiometric Performance

12) The System shall collect reflective image data (spectral bands 1-9) providing signal-to-noise ratios at least as high as those specified in Table 3 for at-aperture spectral radiance $L_{Typical}$ when measured over periods of up to one WRS scene.

13) The System shall collect thermal image data (spectral bands 10-11) with Noise Equivalent Delta Radiance (NEdL) less than or equal to those specified in Table 3 when measured over periods of up to one WRS scene.

Table 3 Signal-to-Noise Ratio (SNR) Requirements

#	Band	SNR @ LTypical	Radiance Level for SNR, $L_{Typical}$ (W/m^2 sr µm)
1	Coastal Aerosol	130	40
2	Blue	130	40
3	Green	100	30
4	Red	90	22
5	NIR	90	14
6	SWIR 1	100	4.0
7	SWIR 2	100	1.7
8	Panchromatic	80	23
9	Cirrus	50	6.0
#	Band	Noise Equivalent Delta Radiance (NEdL)	
10	Thermal 1	0.059 W/m2 sr µm	
11	Thermal 2	0.049 W/m2 sr µm	

Radiometric Accuracy

14) The System shall relate reflective data (bands 1-9) within the Level 1 data products to Top of Atmosphere (TOA) reflectance with an absolute radiometric uncertainty of less than 3%, 1-sigma.

15) The System shall relate reflective data (bands 1-9) within the Level 1 data products to at-aperture radiance with an absolute radiometric uncertainty of less than 5%, 1 sigma.

16) The System shall relate thermal data (bands 10-11) within the Level 1 data products, after calibration, to at-aperture spectral radiance with an absolute radiometric uncertainty as specified in Table 4.

Table 4 System Thermal Band Radiometric Performance

Equivalent Blackbody Temperature Range	Absolute Radiance Uncertainty (1-sigma)
260K - 330K	<2%
240K - 260K	<4%
330K - 360K	<4%

Dynamic Range

17) The System shall be capable of observing up to the radiances in Table 5 without saturating.

Table 5. System Reference Radiances

#	Band	Typical Radiance, L_{typ} (W/m^2 sr µm)	Saturation Radiance, L_{max} (W/m^2 sr µm)
1	Coastal Aerosol	40	555
2	Blue	40	581
3	Green	30	544
4	Red	22	462
5	NIR	14	281
6	SWIR 1	4.0	71.3
7	SWIR 2	1.7	24.3
8	Panchromatic	23	515
9	Cirrus	6.0	88.5
10	Thermal 1	9.64	20.5
11	Thermal 2	8.94	17.8

Bright Target Response

18) For the reflective bands (1-9), when an image pixel "X" is exposed to a radiance level of up to 1.5 times that of the saturation radiance, any pixel "Y" outside the 11 x 11 pixel region around image pixel "X" shall not have the "Y" signal changed by more than 1% of its $L_{Typical}$ for bands 1-7 and 9 and shall not have the "Y" signal changed by more than 2% of its $L_{Typical}$ for band 8 as compared to its response when image pixel "X" is exposed to $L_{Typical}$.

19) For the thermal bands (10,11), when an image pixel that has been exposed to a pixel-sized area at a radiance level of less than or equal to that corresponding to a blackbody temperature of 500K, the pixels outside the 11 x 11 region around that pixel are not altered by more than 1% of their radiance at or above 300K.

20) Polarization Sensitivity: The reflective bands 1-9 polarization sensitivity, as defined by the linear Polarization Factor (PF), shall be less than 0.05, where PF = (Imax-Imin) / (Imax+Imin).

Radiometric Stability

21) The average radiometric response (i.e., average radiometric gain) of the system for each of the reflective bands (Bands 1 – 9) shall vary by less than 1% (2 sigma confidence interval) over any 16-day period.

22) The average radiometric response (i.e., average radiometric gain) of the system for each of the thermal bands shall vary by less than 0.7% (1 sigma confidence interval) over any 40-minute period.

Radiometric Uniformity

23) The standard deviation of all pixel column average radiances across the FOV within a band shall not exceed 0.5% of the average radiance after radiometric calibration using the same gain calibration coefficients for all targets, for:

a) Reflective band images (bands 1-9) of uniform scenes with of targets having spectral characteristics as follows (see Appendix C):

- Spectral radiance from bare desert soil as observed through a dry atmosphere (excluding band 9)
- Spectral radiance proportional to the TOA solar irradiance
- Spectral radiance from a dense vegetation target as observed through a moist atmosphere (excluding band 9)

b) Thermal band images (bands 10-11) of uniform scenes with radiance corresponding to a blackbody temperature above 260K and below 330 K.

Geometric Performance

24) The System shall produce Level 1T data products for the reflective bands 1-9 with geodetic pixel uncertainty of less than 12 meters circular error at the 90% confidence level referenced to the World Geodetic System, 1984 (WGS84) geodetic reference system.

25) Thermal data (bands 10-11) within the Level 1T data products shall have a geodetic pixel accuracy of 42 meters circular error at the 90% confidence level referenced to the World Geodetic System, 1984 (WGS84) geodetic reference system.

26) The System shall produce Level 1T data products for the reflective bands 1-9 with a band-to-band co- registration uncertainty of less than 4.5 meters in the along- and cross-track directions at the 90% confidence level.

27) Thermal data within the Level 1T data products shall have a thermal band-to- thermal band co-registration accuracy of 18 meters in the along- and cross-track directions at the 90% confidence level.

28) Level 1T data products shall have band-to-band registration co-registration accuracy of 30 meters or less in the along and cross-track directions at the 90% level of confidence between bands 1-9 and the two thermal bands.

29) Reflective data within any two Level 1T data products covering the same earth surface area with data collected on different dates shall co-register, image-to- image, with an uncertainty of less than 12 meters in the along- and cross-track directions at the 90% confidence level, when projected to the WGS84 Earth ellipsoid surface.

30) Thermal data within the Level 1T data products shall have internal accuracies sufficient to achieve an image-to-image co-registration accuracy of 45 meters in the along- and

cross-track directions at the 90% confidence level, when projected to the WGS84 Earth ellipsoid surface.

31) Corresponding pixels from the two thermal bands in TIRS data and the nine reflective bands in OLI data that have been geometrically corrected including compensation for the effects of terrain relief shall be co-registered with an uncertainty of 30 meters or less in the line and sample directions at the 90% confidence level.

32) Reflective data (bands 1-9) shall have a geodetic pixel location uncertainty of less than 65 meters circular error at the 90% confidence level referenced to the WGS84 reference system without ground control knowledge, excluding the effects of terrain.

33) Thermal data (bands 10-11) shall have a geodetic pixel location accuracy of less than 76 meters circular error at the 90% confidence level referenced to the WGS84 reference system without ground control knowledge, excluding the effects of terrain.

Appendix A: Stray Light Rejection Requirements

Definition: A light rejection scene or a scene to assess internal light scattering is defined as follows (Figure A-1):
The system image data are collected from a circular region having a radius = 0.25 degrees and having a uniform target radiance = L_T.
That target region is surrounded by an annular region having an inner radius = 0.25 degrees and an outer radius = 25 degrees and having a uniform background radiance = L_B.
When $L_B = L_T$, the system image data radiance measured at the center of the target region has a nominal value = L_T.
All angles are measured relative to the system nadir view.

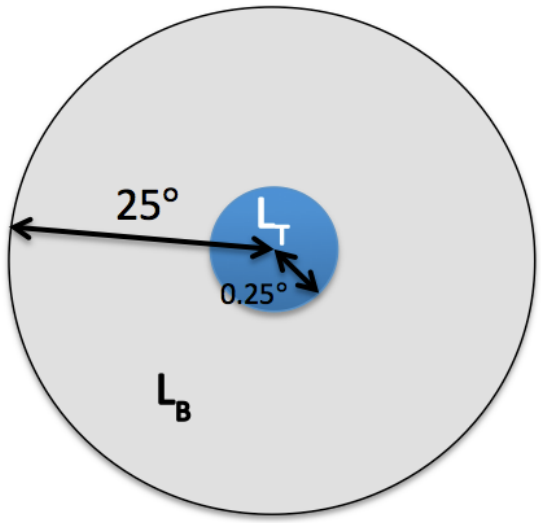

Figure A-1

Reflective (bands 1-9) requirement: The magnitude of the change in the image measured radiance at the center of the light rejection scene shall be less than 0.004 times the magnitude of the difference between L_B and L_T, where target and background radiance levels range from a minimum of zero to a maximum of L_{Max}, such that $L_T - L_B$ ranges from a minimum of $-L_{Max}$ to a maximum of $+ L_{Max}$.

Thermal (bands 10-11) requirement: The magnitude of the change in the image measured radiance at the center of the light rejection scene shall be less than 0.004 times the magnitude of the difference between L_B and L_T, where the target radiance is $L_{typical}$ and background radiance levels range from a minimum of L_{240K} to a maximum of L_{330K}.

Appendix B: Ghosting Requirements

For two dimensional objects up to 1.5° by 1.5°:

At a radiance level at or above 98% of Lmax, and

Located at a position anywhere in the telescope(s) full FOV, the signal from the object at N pixels away from the object edge shall be less than the values in Table B-1. (see Figure B-1)

Table B-1. Ghosting Requirements

30 m Reflective; 120 m Thermal	
Distance From Object Edge (N)	**Maximum Signal**
Between 1 and 10 pixels	≤ linear threshold from 5% of L_{max} at 1 pixel to 6.5% of L_{typ} at 10 pixels, monotonically decreasing
Between 10 - 30 pixels	< linear threshold from 6.5% of L_{typ} at 10 pixels to 2% of L_{typ} at 30 pixels, monotonically decreasing
>30 pixels	< 2% of L_{typ}

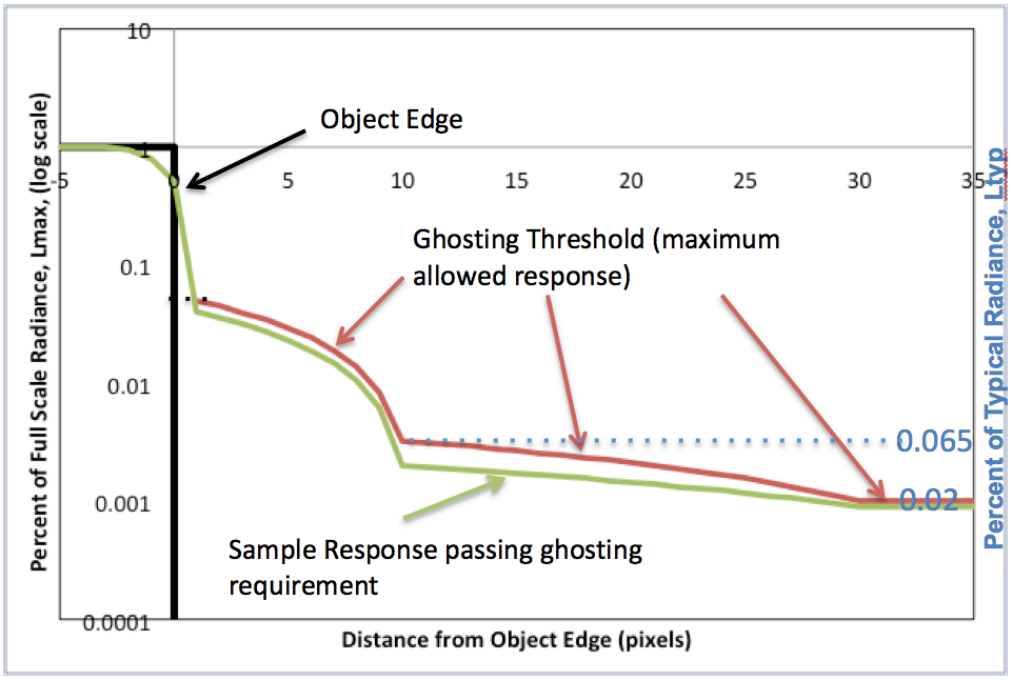

Figure B-1 Sample Ghosting Requirement (note that the ratio of L_{typ} to L_{max} makes this requirement different for each band.)

Appendix C: Reference Radiance Spectra

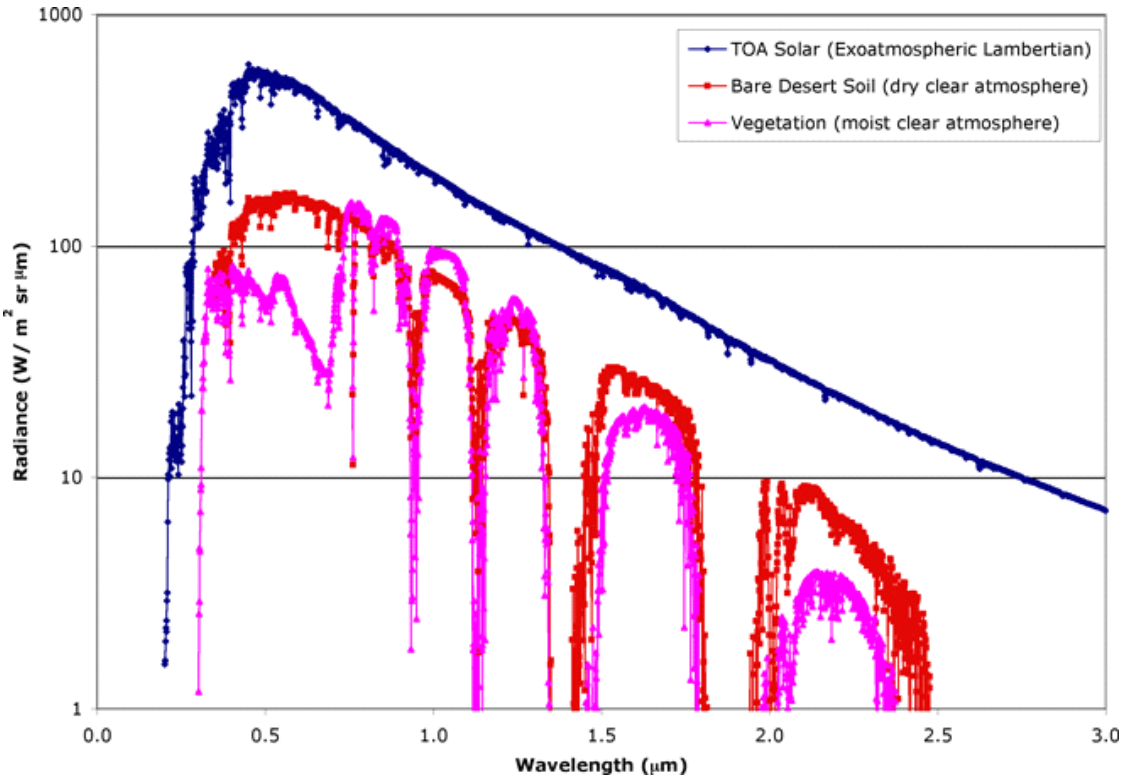

Figure C-1 Top of Atmosphere Spectra for Uniformity Analyses